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HOST RELATIONS OF COMPSILURA CONCINNATA MEIGEN, AN IMPORTANT TACHINID PARASITE OF THE GIPSY MOTH AND THE BROWN-TAIL MOTH

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The depredations wrought by the gipsy moth (*Porthetria dispar* L.) and the brown-tail moth (*Euproctis chrysorrhoea* L.) in eastern Massachusetts have been responsible for the introduction of many European parasites into the United States. Among the imported parasites which were successfully established is *Compsilura concinnata* Meigen, a tachinid fly common to the European countries where the brown-tail moth is found and credited with a long and varied host list. This parasite was first introduced into Massachusetts in 1906 and found to be generally distributed over considerable territory in 1909. A brief account of the life history, colonization, etc., of this tachinid appeared in a bulletin by Howard and Fiske issued by the Bureau of Entomology in 1911 (*7*),[2] and a much more elaborate summary, detailing the life history, was published by Culver in 1919 (*2*). Tothill (*9*), in 1922, also published on the life history of Compsilura.

Since the establishment of a foreign insect in a new environment may bring about some change either beneficial or detrimental to its hosts and host affiliations, plans were made to study the effect of this introduced parasite on native larvæ. Accordingly, during the spring

[1] The writers are indebted to the personnel of the Gipsy Moth Laboratory for their assistance; to H. G. Dyar, of the U. S. National Museum, and the late F. H. Mosher, of the Gipsy Moth Laboratory, for identification of the Lepidoptera; and to C. F. W. Muesebeck for determination of the Hymenoptera.

[2] Reference is made by number (italic) to "Literature cited," p. 31.

of 1915, arrangements were made by A. F. Burgess, in charge of the gipsy-moth investigations at Melrose Highlands, Mass., for the collection of larvæ and the study of their parasites.

SOURCES OF COLLECTIONS AND DATA

The laboratory is so situated that the opportunities for obtaining large collections of insect material are numerous. In addition to the laboratory force, quarantine inspectors in infested areas, scouts, local moth superintendents in Massachusetts, and people interested in the moth work in all of the New England States gather material and send it to the laboratory for study. The larval collections received from 1915 to 1922 include the following: For 1915, 68 species, 18,457 larvæ; 1916, 151 species, 20,712 larvæ; 1917, 140 species, 23,086 larvæ; 1918, 117 species, 20,427 larvæ; 1919, 141 species, 54,628 larvæ; 1920, 144 species, 58,313 larvæ; 1921, 136 species, 57,512 larvæ; 1922, 138 species, 49,421 larvæ.

During the eight years in which larvæ have been collected there have been received at the laboratory about 300 identified species, together with many specimens which failed to produce adults and the identity of which can never be established. A list of the host insects of Compsilura received during this period is given in Table 1.

TABLE 1.—*List of host insects of Compsilura concinnata Meig. received at the gipsy moth laboratory, Melrose Highlands, Mass., from 1915 to 1922, inclusive* [1]

	1915	1916	1917	1918	1919	1920	1921	1922	Total
Aglais milberti Godart	0	0	*355*	*2,337*	0	0	0	0	2,692
Alypia octomaculata Fabricius	80	3	*31*	12	*37*	*166*	*375*	*179*	883
Ampelophaga myron Cramer	0	0	0	0	0	*16*	0	2	18
Anisota rubicunda Fabricius	2	2	10	144	889	42	*516*	0	1,605
Anisota senatoria Smith and Abbot	20	0	0	48	*530*	200	*798*	516	2,112
Anosia plexippus Linné	0	61	*70*	*192*	0	0	0	*33*	356
Apatela americana Harris	1	2	52	4	2	*6*	0	1	68
Apatela furcifera Guenée	0	*10*	*19*	*10*	4	*31*	*5*	*4*	83
Apatela brumosa Guenée	0	*4*	8	*27*	4	20	0	0	63
Apatela sp	0	0	2	*2*	*2*	2	1	3	12
Arctiid	0	0	4	*10*	*16*	4	0	0	34
Arsilonche albovenosa Goeze	0	*47*	4	*120*	95	*21*	6	0	293
Autographa brassicae Riley	42	48	391	*167*	37	*103*	*269*	129	1,186
Automeris io Fabricius	0	91	18	1	0	2	1	*29*	142
Basilarchia archippus Cramer	20	*16*	*53*	*119*	*245*	*184*	*172*	*52*	811
Basilarchia astyanax Fabricius	0	3	0	0	0	0	*3*	3	9
Callosamia promethea Drury	*755*	284	537	*661*	53	20	12	9	2,331
Calpe canadensis Bethune	10	1	1	0	*31*	18	1	19	81
Catocala sp	0	5	1	2	7	12	15	*8*	50
Cerura occidentalis Lintner	0	3	4	2	1	16	6	*5*	37
Charidryas nycteis Doubleday and Hewitson	0	0	0	0	*36*	54	101	18	209
Cimbex americana Leach	*19*	3	24	*16*	41	27	38	1,590	1,758
Cingilia catenaria Drury	0	0	0	0	*501*	436	398	*974*	2,309
Cirphis unipuncta Haworth	15	0	0	0	*6*	2	17	10	50
Cnidocampa flavescens Walker	0	12	392	0	0	0	0	*1,195*	1,599
Croesus latitarsus Norton	20	494	609	*567*	*2,868*	*1,405*	*2,130*	*1,187*	9,280
Datana angusii Grote and Robinson	0	0	*35*	0	69	0	40	37	181
Datana integerrima Grote and Robinson	0	65	7	*327*	0	*478*	0	0	877
Datana major Grote and Robinson	0	*42*	*1*	0	3	0	17	*60*	123
Datana ministra Drury	0	224	*2,449*	*432*	199	*259*	*955*	*299*	4,817
Datana perspicua Grote and Robinson	0	0	0	0	0	*120*	*152*	308	580
Deidamia inscriptum Harris	*9*	0	1	2	1	0	0	0	13
Deilephila gallii Rottemburg	*12*	0	0	0	1	1	0	0	14
Deilephila lineata Fabricius	0	2	1	0	0	0	2	*8*	13
Diacrisia virginica Fabricius	*161*	*118*	*184*	*328*	8	*20*	*18*	*19*	856
Ennomos subsignarius Hübner	*1,200*	*865*	403	*353*	257	2	0	0	3,080
Epargyreus tityrus Fabricius	0	21	0	0	0	*65*	*62*	*226*	374

[1] Numbers in italic indicate that Compsilura was reared.

TABLE 1.—*List of host insects of Compsilura concinnata Meig. received at the gipsy moth laboratory, Melrose Highlands, Mass., from 1915 to 1922, inclusive*—Continued

	1915	1916	1917	1918	1919	1920	1921	1922	Total
Epicnaptera americana Harris	0	4	6	*9*	*4*	3	3	4	33
Estigmene acraea Drury	25	*208*	*696*	*185*	*619*	*105*	*106*	*114*	2,058
Euchaetias egle Drury	0	*152*	*675*	*345*	*497*	*72*	*155*	*779*	2,675
Eugonia j-album Boisduval and Leconte	16	43	2	*13*	0	0	0	0	74
Euproctis chrysorrhoea Linné [2]									
Euthisanotia grata Fabricius	0	0	*8*	0	0	3	0	0	11
Euvanessa antiopa Linné	*250*	*551*	*418*	*2,243*	*667*	*430*	*1,124*	*1,075*	6,758
Evergestis straminalis Hübner	20	14	*11*	2	0	48	0	5	100
Halisidota caryae Harris	0	367	*1,647*	*47*	250	4	4	22	2,341
Halisidota tessellaris Smith and Abbot	0	229	*1,572*	255	26	34	12	*161*	2,289
Hemaris thysbe Fabricius	0	0	0	0	0	*77*	22	6	105
Hemerocampa leucostigma Smith and Abbot	0	*99*	*222*	*480*	*60*	*781*	*543*	*1,937*	4,122
Hemileuca maia Drury	685	195	*934*	*3,059*	2,730	780	*2,004*	*955*	11,342
Heterocampa guttivitta Walker	0	*3*	3	*276*	*1,749*	*842*	3	0	2,876
Heterocampa umbrata Walker	0	0	0	0	*10*	0	0	0	10
Hydria undulata Linné	0	0	71	87	1,161	817	419	*560*	3,115
Hyphantria cunea Drury [3]	0	836	1,373	*1,671*	7,577	*8,623*	2,940	2,478	25,498
Lycia cognataria Guenée	0	0	0	*28*	3	*35*	6	9	81
Malacosoma americana Fabricius [4]	8,650	*2,099*	1,156	*810*	13,574	10,832	*4,850*	*966*	42,937
Malacosoma disstria Hübner	*2,520*	*278*	57	*207*	302	*548*	*679*	*688*	5,079
Mamestra adjuncta Boisduval	0	*11*	6	5	1	4	0	4	31
Mamestra legitima Grote	0	2	6	*5*	3	3	2	2	23
Mamestra picta Grote	206	*584*	*340*	9	291	166	118	18	1,682
Melalopha inclusa Hübner	0	0	0	*50*	*261*	456	257	45	1,069
Nadata gibbosa Smith and Abbot	0	2	3	0	*8*	*7*	0	12	32
Notolophus antiqua Linné	*8*	*5*	*99*	*21*	*3*	0	*7*	106	249
Olene basiflava Packard [5]	10	*2,543*	*399*	*12*	153	0	90	3	3,210
Olene sp	0	0	0	*1*	0	0	0	0	1
Paonias myops Smith and Abbot	0	2	0	20	0	*59*	5	19	105
Papilio polyxenes Fabricius	35	*49*	179	*8*	*71*	*20*	*62*	*42*	466
Papilio troilus Linné	0	0	2	0	0	*78*	72	53	205
Papilio turnus Linné	*2*	2	*7*	3	3	*58*	*13*	*8*	96
Pheosia rimosa Packard	0	0	0	*1*	0	*16*	5	1	23
Phigalia titea Cramer	*396*	527	54	*8*	3	6	1	15	1,010
Phlegethontius quinquemaculata Haworth	3	*89*	*79*	1	*202*	*109*	6	37	526
Pholus achemon Drury	0	0	0	0	0	*1*	0	0	1
Plathypena scabra Fabricius	0	0	0	0	*237*	1	1	0	239
Plusiodonta compressipalpis Guenée									
Polygonia comma Harris	*1*	0	0	0	0	0	0	0	1
Polygonia interrogationis Fabricius	0	6	0	*79*	*266*	*10*	7	0	368
Pontia rapae Linné [6]	*0*	*174*	*1,139*	*256*	*1,234*	*1,368*	*1,030*	222	5,423
Porthetria dispar Linné [2]									
Pteronidea ribesi Scopoli	300	500	524	162	1,980	552	521	*1,584*	6,123
Pyrophila pyramidoides Guenée	0	24	3	*5*	*8*	9	0	10	59
Rhodophora florida Guenée									
Samia cecropia Linné	4	7	31	2	7	8	3	*12*	74
Schizura concinna Smith and Abbot	*85*	*449*	*3,473*	*2,074*	*3,603*	*1,995*	*498*	*187*	12,364
Schizura unicornis Smith and Abbot	0	3	1	4	1	4	*4*	9	26
Scoliopteryx libatrix Linné	0	0	0	0	*2*	3	0	7	12
Sphecodina abbotii Swainson	0	13	13	9	13	14	*10*	12	84
Sphingid larva	0	0	0	0	0	*1*	0	0	1
Sphinx gordius Stoll	0	1	1	0	4	*19*	3	6	34
Stilpnotia salicis Linné [7]	0	0	0	0	0	*627*	0	0	627
Thanaos sp	0	0	0	0	0	83	*55*	3	141
Telea polyphemus Cramer	12	3	18	*3*	2	2	3	2	45
Tenthredinid larvæ [8]	0	150	*215*	25	153	805	47	*181*	1,576
Tenthredinid larvæ [9]	0	0	0	0	0	0	*86*	0	86
Vanessa atalanta Linné	*25*	0	9	*266*	*683*	*143*	5	88	1,219
Vanessa huntera Fabricius	0	*1*	0	1	18	*25*	3	7	55
	15,619	12,601	21,118	18,630	44,382	34,168	21,894	19,377	187,789

[2] Collections of E. chrysorrhoea and P. dispar are not included in this table. These collections, numbering several thousand larvæ, are made each year for various purposes and are handled by the laboratory force.

[3] Nearly 6,000 larvæ of H. cunea were received in 1921 and 9,000 in 1922, but the writers were unable to handle more than the number listed.

[4] Nearly 25,000 larvæ of this species were received in 1921 and 20,000 in 1922, but the writers were unable to handle more than those listed.

[5] Collections of O. basiflava include the hibernating larvæ of which 90 per cent died from unknown causes.

[6] Large collections of P. rapae were received at the laboratory during 1914 and 1915 but were used by Culver (*2*) in his life-history experiments.

[7] Collections received during 1922 and 1923 were handled by the laboratory force.

[8] Neurotoma fasciata Norton.

[9] Pteronidea coryla Cresson.

The territory from which the collections were received is representative of the gipsy-moth area of New England, the bulk of the material, however, being from those sections about Melrose Highlands, Mass.; Bangor, Me.; Claremont, N. H.; Westerly, R. I., and Putnam, Conn.

There are also collections (not included in the above summary) from the gipsy-moth territory in New Jersey. In this area there had been prior to 1921 no systematic introduction of parasites and the material obtained answers well for check purposes. These collections are represented by over 125 species aggregating at least 10,000 larvæ.

CARE OF COLLECTIONS AND METHODS OF REARING

Ordinary mailing tubes, 2 inches in diameter and 7 inches long, with screw tops, are used with great success for the shipment of material from the field. On receipt of the collections at the laboratory the contents are sorted, identified if possible, and placed in receptacles for rearing.

Various methods are used in handling the collections. In the case of known insects the task is easy since many species can be successfully reared in pasteboard boxes or in covered trays. The framework of these trays is of wood, measuring 12 by 12 by 5 inches; the bottom is covered with cloth and can readily be replaced when necessary. All trays are furnished with tightly fitting glass covers which slip into a grooved top. Where there is any doubt as to how the species may best be reared, glass jars, supplied with earth, are used.

Hibernating larvæ and species which pass the winter as pupæ or prepupæ are difficult to handle successfully. In caring for the hibernating larvæ the best results were obtained from the use of Riley cages. For pupal hibernation, glass jars, galvanized-iron cylinders with bottoms of fine mesh wire screening, and wooden boxes of various sizes are used. These are partially filled with earth and the larvæ allowed to transform at will. The glass jars are either retained in the outside rearing cage or brought into the cellar of the laboratory, where they are not subject to extreme temperatures. The cylinders and boxes which have been successfully used are set in the earth as soon as the larvæ pupate, and covered with straw. Practically the same methods are used in caring for the tachinid and hymenopterous parasites.

LIFE HISTORY AND HIBERNATING HOSTS

Briefly, the life history of *Compsilura concinnata* is as follows: During the spring the last-stage larvæ issue from their hibernating hosts and pupate close by. Ten days or so later the adults appear. In New England there are two or more generations upon alternate hosts, the progeny of the last generation hibernating as larvæ within certain lepidopterous pupæ. Spring emergence of the overwintering generation is variable, depending upon climatic conditions (Table 2). During 1921 a few flies issued in April, whereas the material collected in 1916 gave no results in 1917 until June 11 and later. Most of the rearing records, however, which have been conducted

under natural conditions show a much earlier date of emergence. In the field, collections of adults range from May 1 to November 1.

TABLE 2.—*Showing the emergence of hibernating flies from their host pupæ (natural environment)*[1]

Date of individual emergence	Host	Period of emergence
1916		
June 8, 10, 12	Deilephila gallii Rottemburg	June 3–12.
June 3	Diacrisia virginica Fabricius	
June 6, 12	Callosamia promethea Drury	
1917		
June 11	Arsilonche albovenosa Goeze	June 11–15.
June 13	Apatela brumosa Guenée	
June 14	Apatela furcifera Guenée	
June 15	Papilio polyxenes Fabricius	
1918		
May 24, 27	Diacrisia virginica Fabricius	May 24–June 6.
June 6	Schizura concinna Smith and Abbot	
1919		
May 27	Apatela furcifera Guenée	May 27–June 10.
May 27, 29, 31	Hyphantria cunea Drury	
May 27, 28, 31	Apatela brumosa Guenée	
May 28–31, June 10	Euchaetias egle Drury	
May 28	Arsilonche albovenosa Goeze	
May 29	Pontia rapae Linné	
May 31	Pheosia rimosa Packard	
1921		
Apr. 12–25	Papilio polyxenes Fabricius	Apr. 12–May 28.
Apr. 14	Hyphantria cunea Drury	
May 4	Paonias myops Smith and Abbot	
May 14, 16, 24	Pontia rapae Linné	
May 21	Arsilonche albovenosa Goeze	
May 21, 23, 28	Apatela furcifera Guenée	
May 23	Apatela americana Harris	
May 23–24	Estigmene acraea Drury	
1922		
May 1	Estigmene acraea Drury	May 1–June 10.
May 21–June 10	Euchaetias egle Drury	
May 15	Thanaos sp	

[1] No hibernating records for 1920 were obtained.

There are other records of Compsilura being reared from overwintering pupæ of *Diacrisia virginica*, *Callosamia promethea*, *Mamestra picta*, *Mamestra legitima*, *Ampelophaga myron*, *Papilio troilus*, *Sphinx gordius*, *Paonias myops*, *Apatela americana*, and *Deidamia inscriptum*, but since these are all laboratory records, the rearings having taken place under artificial conditions, no mention is made of them in the table. *Schizura unicornis*, which overwinters as a prepupa, has also given Compsilura under laboratory conditions. Among the hosts recorded by Culver (*2*, *p. 5*) are two species, *Plusiodonta compressipalpis* and a geometrid; the record of the former was dated April 7, 1913. Smith (*8*) records a rearing of *Callosamia promethea*, the parasite issuing May 2, 1914. At West Springfield, Mass., in 1915, the same writer succeeded in recovering Compsilura from the overwintering pupa of *Diacrisia virginica*, two flies issuing May 12 to 15, 1916. The conditions under which the rearing took place are not known.

STATUS OF HIBERNATING HOSTS OF COMPSILURA

The abundance of Compsilura in the spring and consequently the degree of parasitism upon the brown-tail and gipsy moths are to

a great extent due to the abundance of its hibernating hosts.[3] With two exceptions (*Schizura concinna* and *S. unicornis*), these host insects pass the winter in the pupal stage either above or below the surface of the earth. The majority of the species are solitary, although a few are gregarious, such as *Hyphantria cunea*, *Euchaetias egle*, and *S. concinna*, colonies of which are usually found each year in some locality or other.

Arsilonche albovenosa, *Diacrisia virginica*, *Mamestra picta*, and *Pontia rapae*, although not strictly gregarious, are often found in large numbers. This is particularly true of *P. rapae*. Probably no native species has been received in such numbers and from so many localities as this insect. As a hibernating host its status is doubtful. Occasionally a fly or two is reared, but considering the hundreds of overwintering chrysalids, the percentage of parasitism is negligible.

Ampelophaga myron feeds on Virginia creeper and grape; it is solitary and is usually found in small numbers. This species is considered common, although none had ever been received by the writers until 1920. It is single-brooded and hibernates as a pupa, and although the collections of this year were heavily parasitized by *Apanteles congregatus* Say, only a single specimen of Compsilura was recovered from overwintering material.

Paonias myops, solitary usually but sometimes found in considerable numbers on wild black cherry, appears to be of little consequence as a winter host. In the collections *Trogus* spp. (*brullei* Prov. and *canadensis* Prov.) and *Apanteles smerinthi* Riley assume prime importance as natural checks.

Sphinx gordius, of the same general habits as *Paonias myops* but with a more varied list of food plants, occupies about the same host status.

Diacrisia virginica is without doubt the most favored overwintering host yet recorded. It is common; a specimen is frequently found here and there and sometimes in the most unexpected places; still it has never been received in abundance.

So much difficulty has been experienced in the rearing of *Mamestra picta* that the records are far from complete. The larvæ are gregarious in the first three stages at least, after which they disperse. The species seems particularly subject to disease and the hibernating pupæ nearly always succumb. If disease is as prevalent in the field as it is in the trays, the chances are slight of its being of much importance as an overwintering host.

Callosamia promethea has been abundantly received from Rhode Island and Connecticut as cocoons and only upon a few occasions

[3] That a higher percentage of parasitism upon the gipsy moth could be reached in an area where there is a mixed infestation of gipsy and brown-tail moths is not borne out by the parasite records. A careful study of these records over a series of years when one or both of the species were present indicates that a very small percentage of the flies issuing from the brown-tail moth are able to attack the gipsy moth. The few that do must necessarily prey upon larvæ of the last stage and here success would not be at all certain. It is doubtful, even though a considerable number of this first generation attacked the gipsy moth, whether their presence could offset the lost efficiency of the parent fly caused by the drain on its reproductive capacity in its attack upon the brown-tail moth. According to Culver (*2, p. 9*), all that can be expected of Compsilura is an average progeny of about 100. Naturally, in a mixed infestation, the parasite would attack the first host that made its appearance. This would be the brown-tail moth. Finding the larvæ abundant and favorable, it would prey upon this host until the appearance of the gipsy-moth larvæ two weeks or so later. By this time its reproductive capacity would have been reduced by the extent of its attack upon the brown-tail moth, and consequently it would be less effective against the gipsy-moth larvæ.

has it given forth Compsilura. Whatever may be its status as a summer host, it is certainly of minor importance as a hibernating one.

There is only one record of an abundance of *Papilio polyxenes*. Usually the larvæ are solitary. A great many adults have been reared and Compsilura often secured. The collections indicate a partial second generation, the insects passing the winter as chrysalids. *P. troilus* is seldom of economic importance and is similar in its life history to *P. polyxenes*. Undoubtedly it is common, although collections have been received only during the last three years. It is one of the most acceptable hosts; and, were it not restricted to certain food plants (sassafras and Lindera), it would rank high in importance as a hibernating host. Collections totaling 65 larvæ made during September, 1920, gave 24 adult Compsilura the following spring—a record for hibernation far ahead of any other met in the writers' studies. As many as five individuals have been known to winter successfully in one host chrysalid.

Apatela furcifera and *A. brumosa* are strictly solitary and, although never plentiful, seem constant in their appearance each year.

There is great difficulty in satisfactorily determining the species of the genus Thanaos, and so the larvæ have been separated according to their food plant. It is only those species which feed upon the oaks that are of immediate concern. Adults, identified as *T. juvenalis* Fab. and *T. horatius* Scud. and Burg., were reared from these collections. Some of the species have at least a partial second generation and the larvæ are found in the field from July to October. Though solitary, they are sometimes found in abundance. Compsilura has been reared from larvæ collected in August, the parasite issuing a few weeks later and also on two occasions from larvæ collected in the fall, the parasite issuing the following spring. The host value of the entire group is uncertain.

GENERATIONS OF COMPSILURA

As will be seen by reference to Table 2, the time of emergence of Compsilura varies from year to year. Doubtless this factor is greatly influenced by climatic and environmental conditions as would also be the number of generations. However, in order to estimate the field appearance of the various generations, there must first be chosen what seems to be an average year. For this purpose, let us say that the period of emergence for the first generation extends from May 24 to June 15. Allowing an 18-day longevity period for the adults,[4] this would extend the range of the first generation to July 3. Granting 30 days for a second generation and a longevity of 18 days for the adult, we would then have flies of the second generation from June 24 to August 22. At the time of the first emergence of the individuals of the second generation, there are still many adults of the first generation in the field. Thirty days later (July 24) adults of the third generation would begin to appear, and it is perfectly possible that stragglers of this generation would be found as late as October. During an extremely mild season a partial fourth generation, the adults of which would issue August 24 and later, is not at all unlikely.

[4] Culver (*2, p. 16*) found that the fertilized females would live for an average of 18 days in confinement and that mated males would live a few days longer. Unmated flies lived but a short time.

The range of Compsilura and the overlapping of generations may be given as follows: First generation, May 24 to July 3 (40 days); second generation, June 24 to August 22 (59 days); third generation, July 24 to October 1 (69 days); fourth generation, August 24 to November.

For the most part it is the progeny of the second to fourth generations that hibernate, for it is rarely that a collection made before September 1 gives Compsilura in the spring. There are exceptions, however, one collection being dated August 22.

STATUS OF SUMMER HOSTS

During the latter part of May and the early part of June, Compsilura finds at hand a good many insects favorable for its development. The flies that issue first attack the hosts then accessible, and the flies that issue later attack not only those but many more. In Table 3 are listed the known hosts of Compsilura, the horizontal black line indicating the presence of host larvæ in the field at the time when they are subject to the attack of the parasite. The records indicate that, although Compsilura may successfully attack early-stage larvæ, the intermediate stages are more acceptable.

TABLE 3.—*Host list of Compsilura concinnata, showing the field appearance of the insects based upon the larval collections received at the gipsy-moth laboratory* [a]

Hosts	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Feb.	Mar.	Apr.
Aglais milberti Godart		———	———	———	——							
Alypia octomaculata Fabricius		———	———	———	——							
Ampelophaga myron Cramer				——	———							
Anisota rubicunda Fabricius		—	———	———	——							
Anisota senatoria Smith and Abbot			——	———	——							
Anosia plexippus Linné			——	———	——							
Apatela americana Harris				———	———							
Apatela furcifera Guenée		—	———	———	———							
Apatela brumosa Guenée		—	———	———	———							
Apatela sp				———								
Arctiid larvæ			——	———	——							
Arsilonche albovenosa Goeze		—	———	———	———	——						
Autographa brassicae Riley			——	———	———	——						
Automeris io Fabricius				——	———	——						
Basilarchia archippus Cramer	———	———	———	———	——							
Basilarchia astyanax Fabricius	——	———	———	——								
Callosamia promethea Drury			——	———	———							
Calpe canadensis Bethune	——	——										
Catocola sp	——	———	—									
Cerura occidentalis Lintner			—	———	———							
Charidryas nycteis Doubleday and Hewitson	———	———	—									
Cimbex americana Leach		—	———	———	———							
Cingilia catenaria Drury		——	———	——								
Cirphis unipuncta Haworth	———	———	———	———	———	———	———					
Cnidocampa flavescens Walker			—	———	———							
Croesus latitarsus Norton		——	———	———	——							

[a] ——— Period in which hosts are subject to attack; ..... period of hibernation (indicating hibernating hosts from which Compsilura has been reared). Adults of Compsilura concinnata issue from hibernating hosts April to June.

TABLE 3.—*Host list of Compsilura concinnata, etc.*—Continued

Hosts	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Datana angusii Grote and Robinson				—	—	—						
Datana integerrima Grote and Robinson				—	—	—						
Datana major Grote and Robinson				—	—	—						
Datana ministra Drury		—	—	—	—							
Datana perspicua Grote and Robinson				—	—	—						
Deidamia inscriptum Harris			—	—	—							
Deilephila gallii Rottemburg			—	—	—							
Deilephila lineata Fabricius			—	—	—	—						
Diacrisia virginica Fabricius				—	—	—	—					
Ennomos subsignarius Hübner	—	—	—									
Epargyreus tityrus Fabricius			—	—	—	—						
Epicnaptera americana Harris		—	—	—								
Estigmene acraea Drury			—	—	—	—	—					
Euchaetias egle Drury			—	—	—							
Eugonia j-album Boisduval and Leconte	—	—	—									
Euproctis chrysorrhoea Linné	—	—	—									
Euthisanotia grata Fabricius				—	—							
Euvanessa antiopa Linné		—	—	—	—							
Evergestis straminalis Hübner			—	—	—	—						
Halisidota caryae Harris			—	—	—	—						
Halisidota tessellaris Smith and Abbot			—	—	—	—						
Hemaris thysbe Fabricius			—	—	—	—						
Hemerocampa leucostigma Smith and Abbot		—	—	—	—	—						
Hemileuca maia Drury		—	—	—								
Heterocampa guttivitta Walker			—	—								
Heterocampa umbrata Walker			—	—								
Hydria undulata Linné			—	—	—							
Hyphantria cunea Drury		—	—	—	—	—	—	—	—	—	—	—
Lycia cognataria Guenée			—	—	—							
Malacosoma americana Fabricius	—	—	—									
Malacosoma disstria Hübner	—	—	—									
Mamestra adjuncta Boisduval			—	—	—	—	—	—	—	—	—	—
Mamestra legitima Grote			—	—	—	—	—	—	—	—	—	—
Mamestra picta Grote			—	—	—	—	—	—	—	—	—	—
Melalopha inclusa Hübner		—	—	—	—	—						
Nadata gibbosa Smith and Abbot			—	—								
Notolophus antiqua Linné		—	—	—	—	—						
Olene basiflava Packard	—	—	—									
Olene sp		—	—									
Paonias myops Smith and Abbot			—	—	—	—	—	—	—	—	—	—
Papilio polyxenes Fabricius		—	—	—	—	—	—	—	—	—	—	—
Papilio troilus Linné		—	—	—	—	—	—	—	—	—	—	—
Papilio turnus Linné			—	—	—	—						
Pheosia rimosa Packard			—	—	—	—	—	—	—	—	—	—
Phigalia titea Cramer		—	—	—	—							
Phlegethontius quinquemaculata Haworth			—	—	—	—						
Pholus achemon Drury			—	—	—							
Plathypena scabra Fabricius				—								
Plusiodonta compressipalpis Guenée					—	—						
Polygonia comma Harris			—	—	—	—						
Polygonia interrogationis Fabricius	—		—	—	—	—						
Pontia rapae Linné			—	—	—	—	—	—	—	—	—	—
Portheria dispar Linné			—	—	—							
Pteronidea ribesi Scopali	—		—	—								

TABLE 3.—*Host list of Compsilura concinnata, etc.*—Continued

Hosts	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Pyrophila pyramidoides Guenee	—	—	—									
Rhodophora florida Guenee				—	—							
Samia cecropia Linné			—	—	—	—						
Schizura concinna Smith and Abbot			—	—	—	—						
Schizura unicornis Smith and Abbot			—	—	—	—						
Scoliopteryx libatrix Linné			—	—	—							
Sphecodina abbotii Swainson		—	—	—								
Sphingid larvæ			—									
Sphinx gordius Stoll			—	—	—	—						
Stilpnotia salicis Linné	—	—	—									
Telea polyphemus Cramer			—	—	—							
Pteronidea coryla Cresson			—	—								
Neurotoma fasciata Norton		—	—	—	—							
Vanessa atalanta Linné		—	—	—	—							
Vanessa huntera Fabricius		—	—	—	—							

There is a great variety of insects among the summer hosts of Compsilura. Three orders are represented and in the Lepidoptera 18 families are included. The species attacked are widely divergent in habit as well as in external appearance. Apparently there are no distinguishing characters peculiar to the host insect. Just what means Compsilura uses to select its host is not known. It is possible that it has no sense of discrimination. Experiments positively show that year after year it will attack hibernating brown-tail moth caterpillars without the least chance of survival. The same behavior has been observed in its relation to *Olene basiflava*. During the winter of 1922 C. F. W. Muesebeck of the gipsy-moth laboratory, while dissecting some of the overwintering larvæ of *O. basiflava*, found a single hibernating larva of Compsilura. It seems certain that the parasite would here meet the same fate as it does in its attack upon the brown-tail moth, but since the writers have been unable successfully to rear many of the overwintering larvæ of the host there are insufficient data to settle this point. It is probable that in most cases the death of the parasite is due to the lack of correlation between the host and the parasite; that is, in the spring, the development of the parasite exceeds that of its host, thereby resulting in the death of both (*7, p. 220*). Culver (gipsy-moth laboratory records) found in his laboratory experiments that, although Compsilura would in many instances larviposit upon the last-stage caterpillars, the results were seldom successful. He found that the silkworm (*Bombyx mori* L.), when attacked in the advanced stages, would often complete its cocoon and the parasites reaching the adult stage would be unable to escape therefrom. He also noted larviposition on a chrysalid of *Pontia rapae* which achieved no results. There are other records of attempted larviposition upon lepidopterous pupæ, all of which resulted in failure. In the laboratory experiments, larvæ of several species have been attacked, but no progeny obtained. It is these facts which lead one to believe that Compsilura uses but little discrimination in its choice of hosts and that it will waste much effort in futile attack upon an unsuitable one.

LIPARIDAE

Among the host insects readily accessible to Compsilura in the spring are species belonging to the family Liparidae. Two of these in particular, the brown-tail moth (*Euproctis chrysorrhoea* L.) and the satin moth (*Stilpnotia salicis* L.), are species hibernating as larvæ and periodic in their abundance. Both of these insects seem to be firmly established in Massachusetts. Although *chrysorrhoea* has several introduced tachinid parasites of importance, it would appear that *salicis* has none of consequence except Compsilura. Without doubt these species are primary hosts.

The remaining species, the gipsy moth (*Porthetria dispar* L.), the white-marked tussock moth (*Hemerocampa leucostigma* S. and A.), and the rusty tussock moth (*Notolophus antiqua* L.), hibernate in the egg stage. As Compsilura does not habitually attack larvæ that have not reached the third stage, its attack upon these species is somewhat later than upon those liparids which hibernate as larvæ. In abundance, *P. dispar* exceeds all of the others by far, and for this reason would naturally be the most advantageous host for Compsilura. Because of the great number of this host, Compsilura need waste no time hunting for a more suitable one, but attacks this species with a vengeance. With such an abundance of favored host material, it follows that Compsilura could reproduce at best and increase in such proportions that there would be at the close of the gipsy-moth season the maximum number of individuals in the field. This is most fortunate, for from now on there is no general infestation of insects to replace the gipsy moth and Compsilura must seek out its host.[5] At times, naturally, there might be in certain localities an ample supply of favored ones, but more often it would be a case of finding a solitary or at least a less abundant species. On the other hand, it may be that because of the fact that there are so many Compsilura in the field the hibernating hosts in and adjacent to a heavily infested area are eventually reduced to a minimum, thereby causing a shortage of winter hosts. Since the amount of parasitism of the gipsy moth by Compsilura is governed largely by the abundance of the first generation, less parasitism should be expected in a heavily infested area. An apparent corroboration of this reasoning appears in the parasite records of the gipsy moth laboratory, which show that the high percentages of parasitism are invariably from the lightly infested areas. In the opinion of the writers, this conclusion is not justified by the facts, the records merely representing a percentage method of reckoning. It seems certain that there is an equal distribution of Compsilura over the entire infested area (fluctuations from year to year in certain localities, due to various causes, excepted) and that if the number of parasites were based upon the

[5] A factor of considerable importance pertaining directly to this subject is that of the dispersion of Compsilura. For several reasons the collections of native larvæ examined by the writers shed but little light on this point. Culver (*2, p. 7*) places the spread of Compsilura at approximately 25 miles per year, basing his claim upon scouting and larval collections, rather an unsatisfactory way to obtain notes on the dispersion, but nevertheless about the only data there are to go by. Tothill (*9, p. 39*) found Compsilura 3 miles away from the colony site two weeks after liberation. This definite record, together with Culver's deductions, would indicate that the tachinid was a strong flier and that under certain conditions a yearly spread of 25 miles might be expected.

proportionate number of larvæ per locality the ratio would be approximately the same.

Hemerocampa leucostigma and *Notolophus antiqua* are apparently double-brooded. Larvæ of these species can be found in the field from June until October. The periodic abundance of the former, usually during the latter part of July, makes it a very desirable host. *N. antiqua* is not at all common but what collections have been obtained usually gave forth a few specimens of Compsilura. Studies made by the writers indicate that it also is a desirable host. There are but few insects among those studied where the competition between the tachinid parasites is so keen as in *Hemerocampa leucostigma*. From data secured by Wooldridge [6] in 1910 we find in *H. leucostigma*, besides a great number of hymenopterous parasites, seven species of Tachinidae:[7] Compsilura, *Phorocera claripennis* Macq., *Tachina mella* Walk., *Frontina aletiae* Riley, *Frontina frenchii* Will., (*Exorista*) *Zenillia amplexa* Coq., and *Winthemia quadripustulata* Fab. Of these tachinids the first four species were the more numerous. The following year collections were again made from this locality with similar results.

No collections were received at the laboratory from 1912 to 1915. In 1916 several small ones were sent from Westerly and Newport, R. I. Only one species of Tachinidae was recovered, *Compsilura concinnata*. In 1917 five collections were received from points in Rhode Island and Connecticut and from these were reared 14 Compsilura and 2 *Zenillia amplexa*.

The infestation of *Hemerocampa leucostigma* at Westerly, R. I., reached its height in 1918, and from seven collections of material sent from this locality there were reared, besides Compsilura, a few *Tachina mella*, *Frontina aletiae*, *Phorocera claripennis*, and several unknown larviform puparia. The parasites obtained in 1918 were somewhat similar to those secured in 1910 and 1911. The native tachinids were far less abundant, however.

Owing to the great decrease in the infestation at Westerly, R. I., in 1919, only two small collections were received from there that year. These collections gave forth 10 Compsilura and 1 specimen of *Frontina frenchii*. It was not until 1920 that there was really an abundance of the species around Boston. The results of the rearings of this year were not sufficient to check the findings of 1910, but they show clearly that Compsilura was the most efficient tachinid parasite present. In fact only one specimen of native Tachinidae was obtained—*Phorocera claripennis*.

In 1921 there was a small outbreak of *Hemerocampa leucostigma* at Everett, Mass., near Boston. A collection of over 500 larvæ of various stages was received at the laboratory, and from these were reared 4 specimens of *Apanteles melanoscelus* Ratz. and 68 tachinid puparia. These puparia were all Compsilura.

The following year collections were again made in the same locality. Over 1,000 larvæ of various stages were collected, and from these were reared two species of Hymenoptera and 67 Compsilura.

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[6] Gipsy moth laboratory notes. A large outbreak of *Hemerocampa leucostigma* occurred around Boston, Mass., in 1910 and 1911. Many collections of material were received at the laboratory and considerable data concerning the parasites were obtained.

[7] With a single exception (Compsilura), these tachinids were the same species as those reared by L. O. Howard at Washington, D. C., in 1897 (*6*).

Later a collection of 171 larvæ was obtained, but no tachinid parasite other than Compsilura was reared. It was not until a small collection of five last-stage larvæ was received on September 20 that any of the native tachinids were recovered, two specimens of *Phorocera claripennis* being bred.

The results obtained from the collections secured at Brooklyn, N. Y., and Philadelphia, Pa. (1921–22), are interesting. The tachinids recovered from this material were the same species as those bred at the laboratory in 1910 and 1911. Furthermore, with hardly an exception, the relative importance of each species was similar. The similarity of records is probably due to the conditions existing; that is, a heavy infestation and the absence of Compsilura.

It is obvious from the records that in a territory where Compsilura is established a light infestation of *Hemerocampa leucostigma* is comparatively free from native tachinid parasites. Such a condition would hardly exist, however, were there not some interference from the exotic parasite. To what extent this interference reaches is problematical, but two things seem assured: (1) There is no excessive parasitism by the native species in localities where the introduced parasite is absent, and (2) the host species must be materially affected by the presence of this additional enemy.

LASIOCAMPIDAE

The lasiocampids *Malacosoma americana* Fab. (the tent caterpillar) and *Malacosoma disstria* Hübn. (the forest tent caterpillar), although close relatives of the liparids and having some points in common, are among the most unfavorable of hosts. Their appearance in the field during May and early June, when there is not an overabundance of insect larvæ of sufficient growth for the early issuing Compsilura, would lead one to believe them most desirable. Such is not the case, however, for hundreds of larvæ of both species have given forth but few parasites.

It is difficult to explain why Compsilura so steadfastly ignores these species. In the case of *Malacosoma americana*, where the species is of the tent-making kind, some interference might be expected on account of this habit; but when the same species is isolated and used in laboratory experiments the results are likewise negative. Reproductive experiments, using the tent-making arctiid *Hyphantria cunea* Dru. (the fall webworm) as a host, have proved that far better results can be obtained under laboratory conditions, where the larvæ are not allowed to web up, than can be obtained from field collections. The field collections nearly always result in failure as far as Compsilura is concerned. It seems clear, in the latter case at least, that the web must offer considerable protection to the larvæ within it. *M. disstria*, which does not make a tent, has a much better host value than *M. americana*.

Another species of this family, *Epicnaptera americana* Harr., appears in the field at a later period and the larvæ are frequently found during the last of August. Unlike the species of Malacosoma, this insect is solitary and is never found in abundance. Its value as a host species is doubtful.

NYMPHALIDAE

The family Nymphalidae offers the greatest number of host insects. Species of the genera Polygonia, Eugonia, Charidryas, Euvanessa, Vanessa, Aglais, and Basilarchia have all given forth Compsilura. With the exception of Basilarchia and Charidryas, which hibernate as larvæ, the life history of these hosts is similar. All except *Charidryas nycteis* are double-brooded, or at least have a partial second generation, and are to be found in the field from early spring until late fall. The larvæ are, for the most part, gregarious, in the early stages, at least.

In this group are to be found the most constant alternate hosts and in some respects the most favored. In percentage of parasitism the rate here is as high as in any other group. In the future other species of this family will no doubt be found to harbor Compsilura. It is useless to speculate, however, on the host possibilities of any species of a given group, for no matter how closely the hosts are allied, they may be unsuitable. For instance, among the arctiids we find favored hosts, such as *Diacrisia virginica* and *Estigmene acraea*, and on the other hand we find species of little or no host value, such as *Hyphantria cunea*, *Phragmatobia fuliginosa*, and *Isia isabella*.

In behavior there is some variance. *Euvanessa antiopa* L. always remains in a colony until the time of pupation and is usually found high above the ground feeding on willow, elm, poplar, and birch. *Eugonia j-album* and *Polygonia interrogationis* do not remain gregarious for so long a period; otherwise their habits are much the same.

One of the most conspicuous examples of competitive parasitism occurs in the spiny elm caterpillar (*Euvanessa antiopa* L.). Collections of this species have been constant and, for one year in particular, abundant (Table 1). Nearly all of the larvæ received were in the last stage. It is doubtful whether we have any other species where there are more data available for studying the relationship which Compsilura bears to a single competing tachinid than in this species. Material has been reared in bulk collections and as individuals. The results have been studied from every angle, and yet it is exceedingly difficult to draw any definite conclusions. Facts ascertained from one year's data and corroborated by a second, or in some cases by a third, are contradicted by the results of the fourth. Conditions are so entirely different each year that it is useless to attempt to arrive at average results. The two tachinids playing such an important part in the control of this species are the native tachinid, *Pelatachina pellucida* Coq., and Compsilura. The former has but a single generation and appears to be peculiar to this host alone.

Not the least of our difficulties in estimating value of these parasites is the great amount of superparasitism which occurs among them.[8] This is still further complicated by a good deal of multiple parasitism.[9] Nearly one-half of the collections received during the eight years of study is subject to the latter phase of parasitism. It

[8] The term "superparasitism" is used to indicate that more than one parasite of a single species attacks the individual host.

[9] The term "multiple parasitism" indicates that two or more different species of primary parasites attack the same individual.

varies in degree from year to year and is shown by the following examples: 1 larva gave 1 Compsilura and 1 Pelatachina; 1 larva gave 3 Compsilura and 1 Pelatachina; 1 larva gave 5 Compsilura and 1 Pelatachina; 1 larva gave 2 Compsilura and 2 Pelatachina; 1 larva gave 1 Compsilura and 2 Pelatachina.

From material reared in bulk, 61 larvæ gave 67 Compsilura and 75 Pelatachina; 100 larvæ gave 69 Compsilura and 15 Pelatachina; 52 larvæ gave 70 Compsilura and 29 Pelatachina; 80 larvæ gave 7 Compsilura and 107 Pelatachina.

The aggregate of superparsitism far exceeds that of multiple parasitism. Individual rearings have shown as many as 4 Pelatachina to a single host and with Compsilura as many as 6 per host. Other collections from which Pelatachina alone was reared furnish striking examples of this sort of parasitism; 5 larvæ gave 15 Pelatachina; 89 larvæ gave 90 Pelatachina.

There are similar records for Compsilura, some of which are as follows: 8 larvæ gave 23 Compsilura; 10 larvæ gave 50 Compsilura; 41 larvæ gave 108 Compsilura.

The presence of a hymenopterous parasite (*Hyposoter* n. sp.) makes the problem still more intricate. Frequent rearings of this species were obtained during 1915 and again in 1919. In 1921, five cocoons were obtained and from these adults were secured in the spring of 1922. This species hibernating in its cocoon is one of the most difficult to rear to the adult stage.

The conclusions drawn from the records of the writers indicate that the presence of Compsilura is not detrimental to any great extent to the native tachinid. It is realized, of course, that there is a considerable amount of duplicate parasitism and that the native tachinid may suffer somewhat through the aggressiveness of Compsilura. On the other hand, the records show that Pelatachina emerges at least two weeks and, in most instances, three weeks before Compsilura; it is no doubt owing to this fact primarily that it is able to compete successfully with the introduced parasite. It is probable that during this period, while its attack is unhampered, its effectiveness is most pronounced and that by the time Compsilura appears the development of its progeny has progressed to such a degree that it is in no way affected by that species. Furthermore, the fact that Pelatachina is single-brooded and has never been recovered from the collections of *Euvanessa antiopa* made in summer months adds much to the credit of Compsilura. The records show that the most that can be expected from this species (Pelatachina) is its check upon the first generation; and, as the host species may be found in the field up to October, it would therefore be allowed to increase without restraint as far as that species is concerned were it not for Compsilura.[10]

Polygonia interrogationis Fab. is an excellent host. It is of little economic importance, and is usually found in small numbers on the elm. In New York, it is somewhat injurious to hop vines but is believed to be held in check by the chalcis fly *Pteromalus vanessae*

[10] Collections received from places outside the Compsilura territory, made during a period of two years, aggregate over 1,000 larvæ. From these collections Pelatachina has frequently been reared, but on two occasions only has any other tachinid been obtained. This species, *Phorocera claripennis* Macq. (two individuals reared), is of apparently little importance in its relation to *E. antiopa*.

Harris (*5, p. 213*). The writers have never succeeded in rearing this parasite, but they have obtained records of two Hymenoptera, *Amblyteles caliginosus* Cress. and *Hoplismenus morulus* Say.

The species *Aglais milberti*, *Vanessa atalanta*, *Vanessa huntera*, and *Polygonia comma* are nearly always found just a few feet above the ground, feeding on nettle and everlasting. The two former usually feed in colonies, the two latter are apparently not so gregarious. All are favorable hosts.

In its struggle with the native tachinids, there is little fear that Compsilura may not be fully capable of taking care of itself; but it is less certain that it can successfully compete with certain Hymenoptera. In the collections of *Aglais milberti* (1917, 1918) there are but two parasites of importance, the hymenopteron *Apanteles atalantae* Pack. and Compsilura. *A. atalantae* is gregarious and is reared more frequently than the tachinid. The latter, however, breeds freely upon this host, and it is a frequent occurrence to rear five or six from a single individual. A few rearing records showing the best examples of superparasitism are as follows:

From a collection of 143 larvæ, 34 were killed by *Apanteles atalantae*, and from the remaining larvæ (109) there were reared 310 Compsilura. No adults of *Aglais milberti* were secured. From a collection of 101 larvæ, 74 were killed by *Apanteles atalantae* and from the remaining larvæ (27) there were reared 41 Compsilura. A single adult *Aglais milberti* issued. From 19 larvæ, there were reared 53 Compsilura. No host adults issued. From 26 larvæ there were reared 40 Compsilura. No host adults issued.

Of the two parasites, Compsilura and *Apanteles atalantae*, the latter has much the advantage, because of its ability to attack the host in an earlier stage. It is probable that, if any parasite which is capable of attacking the early-stage caterpillars should compete with Compsilura, the latter species would be the loser. This is the case as regards *A. atalantae*, for here there is a considerable number of progeny already well advanced in development before the host is subject to the attack of Compsilura. It is assumed that if the host already parasitized by *A. atalantae* was in turn attacked by Compsilura there would be but little chance for its development, since the parasites would crowd it out. This opinion is strengthened by the absence of multiple parasitism in this species. *A. atalantae* attacks the larva in the first and second stages only. This habit, as previously noted, has its advantages; and yet, because of it, those individuals which have reached the third stage and have escaped the attack of that parasite are free to develop without apparent check.[11] It is from the third stage on that Compsilura proves its worth; and, although it probably wastes many of its progeny in futile attempts at parasitism on some already parasitized host, it nevertheless accomplishes its purpose and must be credited with a considerable amount of parasitism.

Vanessa atalanta L., a species closely allied to *Aglais milberti* and similar in habits and behavior, is at times heavily parasitized by Compsilura. For example, a collection of 25 last-stage larvæ

[11] This fact, and also taking into consideration the rearing of a few specimens of (*Exorista*) *Zenillia futilis* O. S. and *Winthemia quadripustulata* Fab., would perhaps indicate some interference from Compsilura.

was received from Deering, N. H., July 30, 1915, and from them 20 Compsilura were obtained. No other parasites were reared; and, since this was the only collection obtained during 1915, there are very few data concerning the species for that year. No material was collected in 1916, and only 9 specimens received during 1917. The species was plentiful during 1918, 1919, and 1920, being especially abundant in 1919. The position occupied by Compsilura in its relation to this species is about the same as in *A. milberti*, except that it is still more complicated by the presence of two native tachinids (*Frontina archippivora* Will. and [*Exorista*] *Zenillia futilis* O. S.). The hymenopteron *Apanteles atalantae* Pack. is present in considerable numbers, but the true struggle lies between the tachinids themselves. There is little to guide us in determining the status of *F. archippivora*. From 25 collections, this species was bred from but 4, and, except in the case of 1 collection, only 5 specimens were recovered. The exception, however, proves somewhat confusing, as in this instance 17 flies were reared from 16 larvæ. Biologically, the species is distinct from the other two, its method of reproduction being that of oviposition on host. The writers' records indicate *Anosia plexippus* as its primary host, although Coquillett (*1 p. 15*) lists it from seven others, among which are two species of the genus Vanessa. Eliminating Frontina, the contest narrows to (*Exorista*) *Zenillia futilis* and Compsilura; and, although there were many more Zenillia reared in 1919 [12], the results of the year previous were much in favor of Compsilura. Parasite summaries of 1918 show five times as many Compsilura as *Z. futilis*. The 1920 results resembled those of 1919, showing but one record of Compsilura. Apparently Compsilura has the worst of the argument and the explanation may lie in its biology. *Z. futilis* belongs to the masiceratine series (species whose reproductive habit is leaf oviposition of microtype eggs), whereas the method of Compsilura is larviposition. The latter species is double-brooded and has a number of hosts. In the species belonging to the first series the capacity for reproduction is enormous, the uterus usually containing hundreds of eggs, whereas Compsilura is far less fecund. Considering the method of reproduction of the former parasite, it is not surprising that it is able to work advantageously, particularly in this instance, where the host is gregarious, the larvæ clustered together on a limited patch of nettle. Superparasitism is obvious in a few of the collections but multiple parasitism is rare, only one instance being recorded (*Z. futilis* and *A. atalantae*).

Charidryas nycteis D. and H. passes the winter as a larva and attains its full growth by the middle of June. Adults issue shortly thereafter and their offspring may be found from late July until the ensuing spring. The food plants are chiefly aster and goldenrod. All of the collections have been small and infrequently received. The species is probably of little host value, since most of the larvæ attain their full development so early in the spring, at about the time when Compsilura emerges.

[12] From 22 collections of this species, Zenillia was reared from 17 and a total of 249 puparia was obtained; Compsilura was present in 6 collections only and only 20 puparia were recovered.

Species of Basilarchia are distinct from any of the above both in larval appearance and in behavior. The species *archippus* Cramer is most commonly received, there being only a few collections of *astyanax* Fab. The food plants of the former are numerous, with poplar and willow most in favor. Like *Charidryas nycteis*, it passes the winter in the second or third larval stage, but not gregariously. The collections of the early-stage larvæ are exceedingly limited, but there are enough data to indicate considerable parasitism by *Apanteles limenitidis* Riley. There is at least a partial second generation, and it is not uncommon to find full-grown larvae up to frost. Although of a solitary nature, *B. archippus* is constant in its appearance and is often found in large numbers. Since the larvæ in the last stages seem to be peculiarly free from insect enemies (there are no rearing records other than Compsilura), few species are better hosts; and, from the records, it is apparent that Compsilura has made the most of its opportunity. From a total of 81 collections, this parasite has been obtained from 35. Free from competition as it is in this case, it its not at all surprising to find a high degree of parasitism. Some rearing results suggestive of this are as follows: 19 larvæ gave 48 Compsilura and 5 *B. archippus;* 17 larvæ gave 34 Compsilura and no *B. archippus;* 10 larvæ gave 17 Compsilura and no *B. archippus;* 3 larvæ gave 9 Compsilura and no *B. archippus;* 12 larvæ gave 21 Compsilura and 2 *B. archippus;* 16 larvæ gave 26 Compsilura and no *B. archippus.*

Obviously there is much superparasitism, and individual rearings have often registered from three to seven parasites per host.

NOTODONTIDAE

Insects of still another group, the Notodontidae, are to be classed with the favored hosts. These insects commonly appear in the field in late summer and specimens can be found until cold weather puts a stop to all insect activity.

Species of the genus Datana (*integerrima* G. and R., *ministra* Dru., *major* G. and R., *perspicua* G. and R., and *angusii* G. and R.) are gregarious and have a variety of food plants. One species or another is usually abundant in restricted localities; and, although Compsilura is commonly reared during the fall, it has never been reared from overwintering pupæ.[13] For some reason, there is great difficulty in rearing some of the Datanas and successfully overwintering the pupæ. This is particularly true of the walnut caterpillar (*D. integerrima*), a species common on black walnut. Because of its great abundance it is of especial interest as a host possibility, but owing to the heavy mortality of the larva when reared under artificial conditions, there are few data for judging its status. About all that can be said is that it has given one or more Compsilura for three years in five. It was from this host, too, that several Compsilura were reared in 1921, establishing a new dispersion record for that parasite.[14]

[13] Since the above was written, Compsilura has been reared on two occasions from overwintering pupæ.

[14] A collection of 200 fourth-stage larvæ collected at the gipsy-moth infestation at Greenport, L. I., August 16, 1921, gave five Compsilura in September, 1921.

Heterocampa guttivitta Walk. and *Heterocampa umbrata* Walk. pass the winter as pupæ. The former is periodic in abundance, the latter never so. It is, in fact, rather rare, only a few specimens reaching the laboratory during the entire period in which collections were made. The food plants of both are chiefly maple and beech. Neither of the species is nearly so favorable as the Datanas.

Melalopha inclusa Hübn. is a tent-making species and hibernates as a pupa. The species feeds on willow and poplar and has been received in abundance during the last three years. *Frontina frenchii*, *Eulimnerium validum* Cress., and *Apanteles sarrothripae* Weed seem to be its chief parasites. The species has given Compsilura several times but it can not be considered highly as a host.

Pheosia rimosa Pack. is solitary; its food plants are willow and poplar. It is uncommon and only during the last year have there been received any good-sized collections. It has about the same status as the species of Heterocampa.

Larvæ of the red-humped caterpillar (*Schizura concinna* S. and A.) are found in the field from July to October. This species hibernates in the prepupal stage under leaves and rubbish. Its food plants are varied, apple, birch, willow, and bayberry being much favored. It is common in many localities and is one of the insects most constantly received. It is at times much favored by Compsilura as a summer host, but is of little consequence as a winter one. It has on one occasion, however, given Compsilura in the spring.

In *Schizura concinna*, Compsilura meets with considerable competition from *Winthemia quadripustulata*, *Phorocera claripennis*, *Phorocera erecta*, and *Gymnophthalma americana* Town. The last named, however, attacks the larvæ in an earlier stage than the rest, and its growth is so far advanced by the time the host larva is attacked by the others that it probably has no trouble in maturing. At any rate, a very good percentage of parasitism is maintained each year by *G. americana*. A summary of the tachinid parasites shows that the combined efforts of the native species (*G. americana* excepted) are less effective than that of the exotic. Such may not always be the case, however, for in its relationship to this host Compsilura is most variable. Certain years have given but a negligible amount of parasitism, whereas others have given a parasitism as high as the most favorable host. The principal hymenopterous parasites seem to be *Hyposoter fugitivus* Say and *Eulimnerium validum* Cress. These species attack the host in the second and third stages, the former usually issuing from the fourth and fifth stages and the latter from the cocoons.

Schizura unicornis S. and A. is apparently a solitary species and has always been received in small numbers, usually during September. The larvæ feed upon a great variety of food plants. There is but one record of rearing Compsilura from it and that was from a full-grown larva collected in the fall, the parasite issuing the following spring.

Cerura occidentalis Lint. also appears to be solitary and the collections of it are always small. The larvæ are found chiefly on willow and poplar. Compsilura has been reared only once, the adult issuing during August from a larva collected in July.

ARCTIIDAE

Differing but slightly from the liparids in behavior and in external appearance are the arctiids. Compsilura shows marked partiality for the species noted below.

The yellow-bear caterpillar (*Diacrisia virginica* Fab.) and the salt-marsh caterpillar (*Estigmene acraea* Dru.) are both common species and, although solitary, are often found in abundance. They have a long period in the field, from June until November, and a great variety of food plants. Both are favorable to Compsilura, particularly the former, it being without doubt one of the most acceptable winter hosts.

The tussock caterpillars *Halisidota caryae* Harr. and *Halisidota tessellaris* S. and A.[15] are gregarious. They are general feeders and are occasionally reported as injurious. There is but one generation, the insects pupating in the fall and passing the winter in that stage. Several of the collections have given hymenopterous parasites, especially those of *tessellaris*, but there are few records of Compsilura. Of the two species, *caryae* is the most favorable.

Euchaetias egle Dru. is also gregarious but, unlike the species of Halisidota referred to above, its food plants are limited and it has never been found by the writers on anything but milkweed. In New England it is apparently single brooded; the larvæ are usually found in August and September, pupating during the latter month and hibernating in that stage. There are a number of parasites both hymenopterous and tachinid, the latter perhaps being the more common. Not only does this species serve as an admirable alternate, but it is also an excellent hibernating host. Four of the five tachinids often bred from *E. egle* are the same species as those secured from *Hemerocampa leucostigma;* that is, Compsilura, *Tachina mella*, *Phorocera claripennis*, and *Frontina frenchii.*

Several other species of this family, solitary in nature, and as yet undetermined, have yielded the parasite. On the other hand, certain species previously cited are for some reason or other seemingly unsuitable.

NOCTUIDAE, AGARISTIDAE, AND PYRALIDAE

In the family Noctuidae are found the most divergent forms both in behavior and in external appearance. Species belonging to the genera Apatela, Arsilonche, Mamestra, Catocala, Nadata, Euthisanotia, Calpe, Pyrophila, Plathypena, Scoliopteryx, Autographa, Cirphis, Plusiodonta, and Rhodophora have all yielded Compsilura.

Only one of these, however, *Autographa brassicae*, has been at all constant in its abundance; and, although Compsilura has been occasionally reared from it, there is little to be said in its favor. In the collections, it is always closely associated with *Pontia rapae* and, like that species, has but few parasites.

Apatela americana Harris is rather a common species, but it is never received in large numbers. It is usually found late in the fall feeding upon maple, oak, and other growth. It is solitary and passes the winter as a pupa. Compsilura and *Tachina mella* have been

[15] *Halisidota tessellaris* is perhaps found more often, in the last stages, as a solitary larva.

reared from overwintering material. *Rogas stigmator* Say has also been bred, five adults issuing in September from a larva collected during that month.

Collections of *Apatela furcifera* Guen. extend over a period of seven years. The larvæ are found in the field from the middle of June until the latter part of September. The food plants of this species seem restricted to the various varieties of cherry. It is not considered uncommon, although it has never been received in abundance. From these collections (83 individuals) there has never been reared any other tachinid than Compsilura. On three occasions only have any hymenopterous parasites appeared, species belonging to the genera Apanteles, Meteorus, and Rogas being bred. *A. furcifera* is of first importance as a summer and winter host of Compsilura.

Apatela brumosa Guen. and another species of Apatela as yet undetermined are never found in abundance but are received in small numbers each year. The insects are usually found in the woodlands, principally on willow, birch, cherry, and oak. Larvæ of these species may be found in the field from the middle of June until September and, although never abundant, are among the most sought of the host insects.

Calpe canadensis Beth. appears early in June; it is common and sometimes plentiful. There seems to be but a single generation, the adults issuing during July. The larvæ feed principally upon meadowrue (Thalictrum) and are somewhat difficult to find because of their protective coloration. Perhaps because of this, only a limited number of Compsilura has been bred.

Scoliopteryx libatrix L. is either double-brooded or else has a very remarkable larval stage. It is a rather rare species in the writer's collections, only 12 specimens having been received in eight years. It is said to hibernate as an adult, the food plants being listed as willow, poplar, and cherry. Unlike many of the noctuids it does not enter the soil to pupate but transforms within its cocoon attached to the twigs of the host plant. Like *Calpe canadensis*, the species is well protected by its coloration and has given a few Compsilura.

The zebra caterpillar (*Mamestra picta* Grote), *Mamestra legitima* Grote, *M. adjuncta* Boisd., and *Pyrophila pyramidoides* Guen. are all acceptable as hosts to Compsilura. They are, as a rule, garden-crop insects, and the two former are at times very abundant. All of them hibernate as pupæ beneath the soil.

Arsilonche albovenosa is ordinarily found on marshland. Cattail (*Typha latifolia* L.) and the various marsh grasses are its chief food plants. It ranges in the field from June until October, hibernates as a pupa, and is considered a favorable host. Besides Compsilura, another tachinid, *Masicera* sp., overwinters in this host. There have also been two hymenopterous parasites bred, *Rogas stigmator* Say and *Microplitis quadridentatus* Prov.

Euthisanotia grata Fab. is rather uncommon. It appears in the field during the latter part of July and feeds principally on grape and Virginia creeper. It is an acceptable host, but the collections have been small and the data give little idea of its true status.

Nadata gibbosa S. and A. is a species not uncommon, appearing in the field during July and August and overwintering as a pupa.

Food plants are given as maple, beech, and birch. It is a favorable host for Compsilura.

The green clover worm (*Plathypena scabra* Fab.) was abundant for one year only. Several good-sized collections were obtained and from them were reared Compsilura, *Winthemia quadripustulata*, and *Archytas aterrima* Desv. The species feeds chiefly on clover but at times causes considerable injury to the pea and bean crops. Hibernation takes place in the adult and pupal stages.

Plusiodonta compressipalpis Guen. and *Rhodophora florida* Guen. are present in the locality, but they have never appeared in the laboratory collections. Both of the records are from Reiff[16] rearings. The species probably hibernate as pupæ.

The army worm (*Cirphis unipuncta* Haw.) is a favorable host for Compsilura. It is found throughout the entire season from May until frost. Hibernation is in the caterpillar stage usually, although the insect is said to overwinter sometimes as an adult. It is of national importance, and serious outbreaks, either locally or over a wide area, are not uncommon. Tachinid flies play an important part in the natural control of this species and their success has probably increased since the advent of Compsilura. During the last eight years only a few collections of *C. unipuncta* were received at the laboratory, but in 1914 several good-sized collections were secured. From these collections there was obtained a very good percentage of parasitism by Compsilura. In the various host and parasite lists where this species appears there are many tachinids recorded but only five of them have been reared at the laboratory. Of these native parasites, *Winthemia quadripustulata* Fab. is the only one of consequence and the recoveries of this species, although many times greater than all of the rest combined, are not comparable to Compsilura. For example: Six collections, totaling nearly 1,000 larvæ (from six localities) gave nearly twice as many Compsilura as Winthemia.

The eight-spotted forester (*Alypia octomaculata* Fab.) is received commonly in small numbers and was once obtained in abundance. The species feeds on grape and woodbine. It hibernates as a pupa and is of little host value. The records show three native tachinid parasites, (*Exorista*) *Zenillia eudryae* Town., *Chaetophlepsis tarsalis* Town., and *Winthemia quadripustulata* Fab., and a few Compsilura. A summary of the parasite records would indicate the superiority of the native species.

Evergestis straminalis Hübn. is of little or no host value at the present time. It is constant in its appearance, however, and might, should there be an absence of favorable hosts, prove more worthy. The insect is found in gardens feeding mostly on radish and turnip. It hibernates as a pupa beneath the soil.

Catocala sp.: The great difficulty experienced in separating the larvæ of this genus necessitated their treatment as a single group. There are at least five species represented in the collections. In most cases the larvæ have been received in small numbers during May and June, sometimes in July. Compsilura was recovered from two larvæ collected in June, 1922. Catocala is of doubtful host value.

[16] William Reiff, Forest Hills, Mass., 1913.

GEOMETRIDAE

Phigalia titea Cram. was very abundant for several years but is now scarcely to be found. It has a variety of food plants, chiefly oak, elm, and chestnut. It appears in the field early in June and hibernates as a pupa. It is not a satisfactory host for Compsilura.

Hydria undulata L. is a somewhat common, gregarious species, the larvæ of which web together the leaves of wild black cherry. Although a great number of collections have been received at the laboratory, it was not until 1922 that Compsilura was recovered. The recovery of 2 adults from 6 larvæ in one case and 11 adults from 200 in another would ordinarily be considered a fair host record, were it not for the fact that all the past collections have resulted in failure. In all probability this host was abundant at a time when there was a shortage of favored ones.

Ennomos subsignarius Hübn. is a gregarious species and was found in great abundance for three or four years, less abundantly the fifth, difficult to find the sixth, and entirely absent the seventh and eighth years. Larvæ appear in the field early in May, complete their larval stages in June, and issue as adults in July. The species feeds on red maple principally and hibernates in the egg stage. It has never been a much favored host.

Cingilia catenaria Dru. has been received in abundance only during the last four years. It appears in the field during late June and has a great variety of food plants, including false indigo, birch, huckleberry, and cherry. The species hibernates in the egg stage. It has given a considerable number of Compsilura and has a better host value than any other of the geometrids.

Lycia cognataria Guen. and an unidentified geometrid are solitary and are never found in abundance; the former feeds on willow and hibernates as a pupa. As host insects their value is small.

LYMNADIDAE

Anosia plexippus L. was received in abundance in 1918 and in smaller numbers the two preceding years. During 1919 to 1921, inclusive, there were no collections received. In 1922, the insect was found in small numbers and the 14 collections received represent only a few individuals. The species is still scarce. Without exception, its food plant is given as milkweed. The species is migratory and winters as an adult in the Southwest. Three native parasites are recorded from it and one of these, *Frontina archippivora* Will., is of prime importance. The two remaining species (*Winthemia obscura* Coq. and [*Exorista*] *Zenillia vulgaris* Fall.) are apparently of little consequence. Frontina appears to meet but little opposition from Compsilura and the sum total of its parasitism is much greater. Over 50 per cent of the collections have given Frontina, whereas Compsilura was recovered from only 11 collections. Superparasitism is common with both species but particularly with Frontina, where the average from one collection of 22 larvæ was 4.86 per individual. The best records found for Compsilura are three adults per individual. Multiple parasitism is uncommon, there being no instance noted by the writers. In a general way, Anosia can be considered a favorable host for Compsilura.

PAPILIONIDAE

The species *Papilio polyxenes* Fab. and *Papilio troilus* L. have been discussed elsewhere in this bulletin. *Papilio turnus* L., a species similar in habit to the others of its genus, has given Compsilura frequently. It is very probable that the future will show this species to be of the same host value as its relatives.

PIERIDAE

The cabbage worm (*Pontia rapae* L.) is nearly always to be found in abundance in some locality or other. It hibernates in the chrysalid stage. It is an acceptable host and, because of its abundance and wide distribution, possesses a certain attractiveness. In 1910, Tothill (*7, p. 223*) succeeded in rearing a great many flies and, in some instances, a total of 40 per cent parasitism was obtained. Some years later, Culver,[17] who had received large collections of this material for life-history work, recorded a fair amount of parasitism, but in no case did he equal the record of the former investigator. In contrast to these records, however, the data obtained by the writers show but little parasitism.

SATURNIIDAE

Callosamia promethea Dru., *Telea polyphemus* Cramer, *Samia cecropia* L., *Automeris io* Fab., and *Hemileuca maia* Dru. are five species of doubtful host value. From the last-named Compsilura has been reared occasionally, but considering the hundreds of larvæ of all stages used in the experiments, the host value of this insect is insignificant.

As has been previously stated, the value of *Callosamia promethea* Dru. as a winter host for Compsilura appears to be negligible. Its status as a summer host is apparently much more important. Since Culver [18] found, while experimenting with this species and Compsilura, that he could readily obtain larviposition and successfully rear adults when using early-stage caterpillars, there seems little doubt that were large collections of early-stage larvæ received, a fair amount of parasitism would be recorded.

The collections of *Telea polyphemus* Cram. have nearly always been made in the pupal stage and no Compsilura were recovered from them. It is sufficient to say that, in three separate collections of one larva each, there were obtained two Compsilura from one of them.

Samia cecropia L. seems to have about the same host status as *T. polyphemus.* The material when collected as cocoons has never given Compsilura. Larval collections, however, show better results. A single instance of the rearing of four flies from nine third-stage and fourth-stage larvæ is recorded.

Automeris io Fab. has a greater host value than any of the saturniids mentioned. Although none of the collections received prior to 1922 has given Compsilura, the recoveries made that year were gratifying. Furthermore, all of the material was from New York, at points well outside the gipsy-moth area. From these records there

[17] Gipsy Moth Laboratory Records, 1917–18.

was established a new dispersion line for Compsilura. (*Phorocera claripennis* Macq. was the only other tachinid reared.)

SPHINGIDAE

Deilephila gallii Rott. and *Deidamia inscriptum* Harr. have both been taken abundantly near lights, but they appear only occasionally in collections received by the writers. The larvæ of both species appear in the field from July until October. The former feed on Galium and primrose, the latter on grape and Virginia creeper. Both species hibernate as pupæ. Their host status is favorable.

Deilephila lineata Fab. was received intermittently over a period of eight years. The larvæ are usually found feeding on Portulaca. There are probably two generations, the later one hibernating as pupæ. Most of the collections were received during September and October. An exception to this was the receipt of one last-stage larva collected July 21, from which two Compsilura emerged August 14, 1922. The host status is favorable.

The northern tobacco hornworm or tomato worm (*Phlegethontius quinquemaculata* Haw.) is constant in its appearance and is in the field from July until October. It feeds on tomato and hibernates in the earth as a pupa. As a summer host it has occasionally given Compsilura, and in all probability would be one of the most favored were it not for *Apanteles congregatus* Say. In this hymenopteron *P. quinquemaculata* finds its worst enemy, and it is with difficulty that specimens of mature larvæ are obtained free of this parasite. Possibly on account of its great size a number of the larvæ harbor both Apanteles and Compsilura. As many as three adult Compsilura per larva have been obtained from material previously parasitized by Apanteles. The species should be a good host for overwintering Compsilura, but since it is difficult to handle in confinement during hibernation there are few data on its fitness.

Hemaris thysbe Fab. has been received but three times in eight years. It has about the same life history as *Phlegethontius quinquemaculata* and feeds chiefly on Viburnum. It is a very acceptable host.

HESPERIIDAE AND CERATOCAMPIDAE

Epargyreus tityrus Fab. has been received in good-sized collections only once in eight years. The species feeds on a variety of food plants, principally locust (*Robinia pseudoacacia* L.) and groundnut (*Apios tuberosa* Moench). It appears in the field during July, and specimens are to be found until late October. It hibernates as a pupa and is of fair value as a host. The parasitism by the Hymenoptera is negligible, as is also the case with the tachinids other than Compsilura. This fly alone has been reared in considerable numbers, especially during 1921.

The orange-striped oak worm (*Anisota senatoria* S. and A.) is abundant at times and has been received in particularly large numbers during the last two years. The species feeds principally on oak and hibernates as a pupa. A few of the collections have given Compsilura, but the native parasites predominate. Among the tachinids, *Frontina frenchii* Will., *Winthemia quadripustulata* Fab., (*Exorista*) *Zenillia ceratomiae* Coq., and *Sturmia* sp. were reared.

The principal Hymenoptera were *Hyposoter fugitivus* Say and *Apanteles anisotae* Mues.

A number of collections of the green-striped maple worm (*Anisota rubicunda* Fab.) were received during 1919 and 1921, most of them coming from Western Massachusetts and New Hampshire. Usually *A. rubicunda* is to be found in company with *Heterocampa guttivitta*. The species feeds principally upon maple and hibernates as a pupa. Several specimens of *Frontina frenchii* Will. and a species of Sturmia have been bred. There is but one rearing record credited to Compsilura.

COCHLIDIIDAE

Native species of the family Cochlidiidae are rarely sent to the laboratory and none have ever given Compsilura. Collections of the exotic oriental moth *Cnidocampa flavescens* Walk. were received in large numbers during 1917 and 1922. The species has but a single generation, the winter being passed in the prepupal stage. During 1922 weekly collections of the larvæ were received, aggregating nearly 1,200 individuals. From this material a single Compsilura was reared, the adult issuing in September. The host value of the species is apparently slight.

TENTHREDINOIDEA

The large elm and willow sawfly (*Cimbex americana* Leach) is constant in its appearance and is in the field from July until September. Only once during a period of eight years has it been abundant and then the infestation was confined to a small area. Willow and elm seem the most favored food plants. There is but one generation, the last-stage larva burrowing in the ground and forming its cocoon, where it passes the winter as a larva, pupating in the spring. It offers little attraction to Compsilura.

Croesus latitarsus Nort. is a very common species found abundantly each year on gray birch. It has at least a partial second generation and larvæ of this species are in the field from the middle of June until October. The larva passes the winter within its cocoon and pupates in the spring. It is possible that Compsilura attacks this species more than is recognized, for the examination of cocoons has revealed a certain amount of unlooked-for parasitism that may be of considerable importance. Dissections have shown that in some instances the cocoons contained adult Compsilura which were unable to work their way out. Culver (gipsy-moth laboratory records) made a similar finding in his experiments with the last-stage larvæ of *Bombyx mori*, the larvæ being freely attacked, the parasite maturing within the host pupa and being unable to emerge because of the tough cocoon.

Neurotoma fasciata Nort. is a gregarious species commonly received each year in fair abundance. The larvæ feed upon cherry, webbing the leaves together and leaving their nest only when they seek the earth for hibernation. The period of hibernation in New England usually extends over two seasons. (Larvæ collected in September, 1920, gave adults in May and June, 1922.) Owing to the extreme difficulty in overwintering the prepupæ, very few adults have been obtained. At most, the parasitism of this species by Compsilura is negligible.

Pteronidea coryla Cress., a rather uncommon species, has been received at the laboratory but twice, in June and September, 1921. Evidently there are two generations, individuals of the later one passing the winter in their cocoons, the adults issuing the following spring. The larvæ are gregarious and feed in colonies on hazel nut (*Corylus americana* Walt.). The collections, aggregating about 100 larvæ, gave mostly adults, there being but one parasite, Compsilura, a female fly issuing in July, 1921.

The imported currant worm (*Pteronidea ribesi* Scop.) has been abundantly received over a period of eight years. There are two or at least a partial second generation, cocoons [18] of either generation overwintering in soil. It is of very little, if any, importance as a host, for Compsilura has been reared from it on only one occasion.

COLEOPTERA

So accustomed have we grown to the ever-increasing host list of Compsilura that a new record obtained from some lepidopteron causes but little comment. There have been but few collections of coleopterous larvæ, however, and none has ever given the parasite. A rearing attended by peculiar circumstances was reported to the writers by C. W. Johnson, of the Boston Society of Natural History, who in 1914 recovered the parasite from the white-pine weevil (*Pissodes strobi* Peck). In September of that year he was looking over some of the mounted specimens of various insects in the Libby Museum at Wolfboro, N. H. One mount containing a terminal shoot of white pine, illustrating the work of the weevil, contained a fly which seemed out of place. Upon inquiry it was found that the mount had been made up as usual and that the fly must obviously have issued after the mount was completed. At Johnson's request the fly was given him, and he identified it as *Compsilura concinnata.* Since there was no puparium in sight, the maggot evidently pupated within the burrow of the host.

RECORDS OF COMPSILURA REARINGS OTHER THAN THOSE RECORDED AT THE GIPSY MOTH LABORATORY

The writers are indebted to D. W. Jones, of the European Corn Borer Laboratory, Arlington, Mass., for the following notes on Compsilura:

Compsilura concinnata Meig. has been bred from the European corn borer (*Pyrausta nubilalis* Hübn.) several times during the last few years. We consider it of little importance as a parasite of that species.

To C. W. Johnson, the writers are indebted for the following:

Thanaos brizo B. and L. April 19, 1920.
Symmerista albifrons S. and A.
(Rearings by E. T. Learned, Fall River, Mass.)
Diprion simile Hartig. April 15, 1921.
(Rearing record of M. P. Zappe, New Haven, Conn.)

EFFECT UPON NATIVE PARASITES

What the final outcome of the introduction of Compsilura will be is for the future to decide. What has been accomplished by the

[18] The species probably hibernates as a larva within its cocoon.

establishment of Compsilura, by its subsequent parasitism upon native species, and by its present relation to the native parasites, is more obvious.

As regards the majority of native parasites there is little to indicate anything detrimental to their welfare in the introduction of Compsilura, except an occasional scarcity of host material brought about by the successful attack of this insect. That this absence of host material is in itself of importance, inasmuch as it might materially change or upset the natural balance already existing, does not seem to be borne out by the records of the writers. It is true that there were no systematic collections of native larvæ prior to 1915 against which to check the larval collections of the last few years; there is, however, first-hand knowledge concerning serious outbreaks of native insects in this locality since 1907. The abundance of any insects for which the introduction of Compsilura might be held responsible, because of its interference with the native parasites of the species in question, has not been recorded. On the other hand, infestations of insects which are due for their periodic outbreaks are, so far as known, not on the increase. That there is a considerable amount of duplicate parasitism, there can be no doubt; and that this would be detrimental to one species or another, must also be true. Such an occurrence would take place in any case, however; and, although the presence of Compsilura probably adds to it, the results are not necessarily serious. It is possible that, because of the rapid larval development of Compsilura, it would crowd out forms which develop more slowly. This probably happens where Compsilura and a native tachinid attack the host simultaneously. If, however, the native tachinid were in a stage of development more advanced than that of Compsilura, the latter would in all probability be the loser. There are few positive data on the rapidity of development of many of the competing species, but it is believed that in some of them the development is much slower than in Compsilura.

What appears best to illustrate an occasion where there is a likelihood of Compsilura usurping the position of a native tachinid is found in its relation to *Tachina mella* Walk. Here is a species far less specialized than Compsilura, its reproductive habit being host-oviposition of a flat macrotype egg. Not only have the two species apparently similar hosts, but in nearly every instance where there is competition the native tachinid is the one that suffers most. That there has been a marked decrease in the number of *T. mella* in the gipsy-moth area since the establishment of Compsilura is probable. The parasite records of the writers show this, and there is corroborative evidence as well. Forbush and Fernald, in 1896 (*4, p. 388*), cited several instances of rearing *mella* from the gipsy moth. It is rare that any *mella* are reared to-day, however, and in their aggregate the larval collections of the gipsy moth are far greater than in the past. Forbush and Fernald (*4, p. 385*) call attention to the great number of tachinid eggs deposited upon gipsy-moth larvæ. It is possible, of course, that these eggs were not all laid by one species; but it is probable that a large percentage of them belonged to *T. mella*, as the records of rearing will show. During the past few years thousands of gipsy-moth larvæ have been sent to the laboratory and less than 1 per cent have tachinid eggs on them. Evidently one of

two things has happened; either *mella* has found a host more favorable than the gipsy moth or it has suffered a marked decrease in numbers. The latter view is the more logical. Compsilura is not entirely responsible for this condition, however, for there must be considered the prodigious waste of eggs by *mella* upon the gipsy moth. In the studies of Forbush and Fernald (*4, p. 386*) made during July, 1895, it was found that, whereas about 29 per cent of the gipsy-moth larvæ had tachinid eggs on them, these were in nearly every case moulted off before hatching. It is obvious that, if this futile attack by *mella* continued at the same rate for several years, there would necessarily be a great scarcity of the species.

There are other instances besides that of *Tachina mella* in which the native tachinids meet with great competition, and a certain amount of duplicate parasitism results, in which the native species appear to be at a disadvantage.

The tachinids *Phorocera claripennis*, *Frontina frenchii*, and *Winthemia quadripustulata* have a great variety of hosts, nearly all of which are also acceptable to Compsilura. Like *Tachina mella* they deposit eggs on the host larva and so are handicapped by the subcutaneous larviposition of Compsilura. Probably *P. claripennis* fares the worst of these species, for with a single exception—*Lophyrus lecontei* Fitch—the host species are mutual. There is evidence to indicate that not only does this species overwinter as a larva within its host pupa, but that it often successfully hibernates in the puparium. This habit is of the greatest importance, for it should be borne in mind that Compsilura depends upon certain lepidopterous pupæ for hibernation and that the number of overwintering individuals is to that extent limited. The hibernating quarters of *claripennis*, on the other hand, are unlimited, and it can depend upon its abundance in the spring for successful competition.

Frontina frenchii and *Winthemia quadripustulata* seem to be the least affected by the presence of Compsilura. As has been previously mentioned, *frenchii* finds an excellent overwintering host in the saturniids and meets there with little competition from Compsilura. There are many examples of the value of *Samia cecropia* as a winter host for *frenchii*. Fiske and Thompson (*3*) reared it in large numbers and mention an instance in which 90 adults were reared from a single cocoon by C. H. T. Townsend. No other species met in the writer's studies proves itself so generous a host.

Of these native tachinids which possess the same general hosts as Compsilura, *Winthemia quadripustulata* seems best fitted for the contest. Not only does it more nearly approach Compsilura in the number of its hosts, but it also has a variety of others from which Compsilura has never been reared. It has, too, a decided advantage over Compsilura, inasmuch as it, like *Frontina frenchii*, has several hosts which are capable of supporting a large number of individuals. Finally, it also has the advantage of hibernation as a full-grown larva or in the pupal state.

Taken as a whole, the native larval collections reveal but few cases of tachinids peculiar to a single host. Among the species attacked by Compsilura, there were found but 10 where there is a single competing tachinid with apparently no other host. Of these, the majority are of no particular host value to Compsilura. In one case only, that of *Euvanessa antiopa* L., is there any serious competition, and here

the native tachinid—*Pelatachina pellucida* Coq.—is well able to hold its own against Compsilura. A spring emergence at least two weeks in advance of Compsilura and an ability to hibernate in a puparium sufficiently guarantee its survival.

EFFECT UPON HOST SPECIES

Data concerning the relation of the native tachinids to their hosts prior to the introduction of Compsilura have been obtained through miscellaneous host records and published accounts of the insect. Data have also been obtained from two years of systematic collecting of native larvæ outside the Compsilura area, together with a few collections of larvæ made in a territory where Compsilura was hardly established.

From comparative data thus obtained and from what can be surmised, it seems very clear that the addition of Compsilura to our fauna has been of great benefit. Not only has it accomplished the purpose for which it was introduced, namely, to act as a primary parasite on the larvæ of the gipsy and brown-tail moths, but the rapidity of its dispersion has exceeded all expectations and it is now found established in an area independent of its primary hosts. It is in this area and especially along the outskirts of the moth infestation that the presence of Compsilura means so much. The reasons are twofold: (1) Its attack upon a light infestation of gipsy-moth larvæ, such as would be found along the border of the infested area, would be, or at least has always been, attended with maximum results, and the check exerted here is of the greatest importance; (2) possible dispersion of the gipsy-moth larvæ by the wind or otherwise in an unscouted area, and subsequent infestation, would result perhaps in complete annihilation by Compsilura. The establishment of Compsilura in this area is, of course, due to the alternate hosts upon which its existence is dependent.

Of the many native hosts from which Compsilura has been reared, at least one-half are decidedly favorable for its development. The fact that Compsilura has, since its introduction into New England in 1906, made its presence felt in no less than 92 species of native insects is in itself a manifestation of its efficiency. So thoroughly has this tachinid established itself in this region that it is now able to act as automatically as any native species whose mission is that of a controlling agent. Surely no better example of its ability to cope with the unexpected can be asked than its encounter with the satin moth (*Stilpnotia salicis*). Here an injurious insect, recently imported from Europe, in a single year appeared in astonishing numbers without the least semblance of control by native tachinids. It is extremely doubtful if any of the native parasites would have proved effective had they had the field to themselves. Fortunately, however, Compsilura had become acclimated, and the control exercised by it was remarkable. From certain last-stage larval collections, there have been obtained as high as 78 per cent parasitism. In their aggregate (last-stage larval collections) they will average at least 50 per cent parasitism. On the other hand, the sum total of the native tachinids obtained from 20 collections is but 19 individuals, less than 2 per cent parasitism. Although this is perhaps one of the most spectacular instances of Compsilura's potency, it is by no means excep-

tional. The accidental introduction of other dangerous insect pests into the United States is probable, and it is possible that Compsilura may again serve as efficiently as in the case just cited.

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